ehp

LESSON:
Mapping in the Time of Cholera

Summary:	Students plot historical data from a cholera outbreak in India in 1992–1993 and draw conclusions from these data.
Lesson Type:	Graphic Organization & Modeling—This lesson has students organize information graphically (e.g., using figures, graphs, and/or webs) or by creating a model.
***EHP* Article:**	"Wind Direction and Its Linkage with *Vibrio cholerae* Dissemination" *Environ Health Perspect* 115:195–200 (2007) http://www.ehponline.org/docs/2006/9391/abstract.html **NOTE: This article is part of the research section of *EHP* and will not be found in the May 2007 *EHP Student Edition*.**
Objectives:	By the end of this lesson, students should be able to 1. map data from a disease outbreak; 2. analyze chronological links among these data; and 3. draw conclusions comparing and contrasting typical and atypical outbreak patterns.
Class Time:	1.5–2 hours, using the software program Google Earth; 60–90 minutes if the students plot the data on a paper maps
Grade Level:	10–12
Subjects Addressed:	Biology, General Science, Earth–Space Science, Environmental Science, Social Studies, Technology Education (if using Google Earth)

▶ **Prepping the Lesson (30 minutes)**

INSTRUCTIONS:

1. Download the abstract for "Wind Direction and Its Linkage with *Vibrio cholerae* Dissemination" in PDF at http://www.ehponline.org/docs/2006/9391/abstract.html. You may find it helpful to print out and read the entire research article for reference and to help guide student questions that may arise during the lesson. **NOTE: This article is part of the research section of *EHP* and will not be found in the May 2007 *EHP Student Edition*.**
2. Review the Background Information, Instructions, and Student Instructions, and decide whether the students will do the activity using Google Earth or a printed map of India.
3. Make copies of the Student Instructions.
4. Depending on the reading levels of the students, print out the full-text article (it is easier to read in PDF).
5. Print out Figure 3 from the research article showing the dissemination of the cholera outbreaks. This can be used as a reference during the lesson and to help check students' understanding as they check their maps with this one from the article.
6. Become familiar with Google Earth, and make sure that it is downloaded onto the computers you will use for this lesson (See Notes & Helpful Hints).

MATERIALS (per student):
- 1 copy of of the abstract for "Wind Direction and Its Linkage with *Vibrio cholerae* Dissemination"
- 1 copy of the Student Instructions
- Computer with Google Earth installed (this lesson can be done in pairs, depending on computer availability) OR a map of India that shows major waterways and the 20 cities listed in the table in Step 4 of the Student Instructions (one pull-out type map per small group of students is recommended)
- If using the map option, string (several feet per group) and pushpins in 10 different colors

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VOCABULARY:
- cholera
- epidemic
- isobars
- monsoon
- pandemic
- waterborne

BACKGROUND INFORMATION:

Cholera is a communicable disease, often waterborne, caused by the bacterium *Vibrio cholerae*. Epidemic outbreaks are not uncommon throughout the developing world, and result in considerable morbidity and mortality in these areas of the world. Cholera is practically unheard of in developed nations, which usually have water treatment and sanitation facilities that facilitate treatment and prevention.

V. cholerae infects the intestines and, in severe cases (about 5% of those affected), causes diarrhea, leg cramps, and vomiting. This, in turn, causes rapid dehydration that can lead to death, sometimes in mere hours.

Typically, cholera outbreaks focus health workers' attention on sanitation issues, particularly downstream of an area experiencing an outbreak. In the *EHP* study upon which this lesson is based (Paz and Broza 2007), a different outbreak pattern is studied. Climate has previously shown to be a vector of cholera; this study sought to isolate wind as a specific intracontinental method of disease spread.

Reference:

Paz S, Broza M. 2007. Wind direction and its linkage with *Vibrio cholerae* dissemination. Environ Health Perspect 115:195–200; available: http://www.ehponline.org/docs/2006/9391/abstract.html.

RESOURCES:

Environmental Health Perspectives, Environews by Topic page, http://ehp.niehs.nih.gov/. Choose Drinking Water Quality, Infectious Disease

Centers for Disease Control and Prevention, Disease listing for cholera, http://www.cdc.gov/ncidod/dbmd/diseaseinfo/cholera_g.htm

Google Earth, http://earth.google.com

Wikipedia, Epidemiology, http://en.wikipedia.org/wiki/Epidemiology

Wikipedia, Monsoon, http://en.wikipedia.org/wiki/Monsoon

World Health Organization, Cholera fact sheet, http://www.who.int/mediacentre/factsheets/fs107/en/

▶ Implementing the Lesson

INSTRUCTIONS:

1. Hand out the Student Instructions, Figure 3, and the full-text article (if applicable). If you are having the students work with printed maps of India, distribute those as well as the pushpins and string.

2. Have students complete the Student Instructions, working either individually, in pairs, or in small groups (suggested for the paper map version of this activity).

3. Discuss student hypotheses about what, other than downstream water flow, could cause the pattern of cholera outbreak seen in this epidemic.

NOTES & HELPFUL HINTS:

1. Advanced students may want to read the entire research article.

2. Test Google Earth before the lesson.

   a. Know how to search locations. Under "View," select "Sidebar." Also be sure that "Toolbar" is visible at the top of the window.

   b. To add a placemark, select the "Push Pin" tool from the toolbar. It is helpful to make each month a different color. These colors may be assigned by the teacher prior to the activity, if desired. A color selection dialog box opens when a placemark is added. Within the lower half of this box, there is a tab for "Style, Color."

   c. To add a path, select the appropriate tool from the toolbar. While the dialog box is still open, click once on each location to place in the desired path. Label the path, and close the box.

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   d. Placemarks and paths appear in the "Places" section of the sidebar.

   e. If map resources are limited, one master map could be prepared as a class.

   f. Students may need help deciphering some of the information in the caption at the bottom of Map Handout 1.

▶ Aligning with Standards

SKILLS USED OR DEVELOPED:
- Communication (written)
- Comprehension (listening, reading)
- Critical thinking and response
- Experimentation (data analysis)
- Graph reading
- Graphing
- Reading maps and legends
- Tables and figures (creating, reading)
- Technological design

SPECIFIC CONTENT ADDRESSED:
- Biomarkers
- Molecular biology
- Disease development and progression
- History of science
- Biotechnology

NATIONAL SCIENCE EDUCATION STANDARDS MET:

Science Content Standards

Unifying Concepts and Processes Standard
- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement

Science as Inquiry Standard
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Life Science Standard
- Interdependence of organisms
- Behavior of organisms

Science and Technology Standard
- Understanding about science and technology

Science in Personal and Social Perspectives Standard
- Personal and community health
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

▶ Assessing the Lesson

Step 3:   Using a printed map or the software Google Earth (which allows you to interact with satellite images of the earth), you are going to plot the path of a cholera epidemic that occurred in India between October 1992 and July 1993. Then you will generate hypotheses about the paths the epidemic followed.

Students will plot all of the cities in the data table. This is a fairly straightforward process in which students place a placemark and name it, using a different color for each month. There are 20 points in all. The resulting map will be similar to Figure 3 from the full-text article (minus the large and small arrows, which are simulated in Step 4).

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Step 5:   Look at how the disease spread chronologically through India. Hypothesize a few possible routes by which the cholera bacterium may have spread through the country. Discuss these ideas with at least one other classmate before proceeding, if you're not already working in groups. Next, begin adding lines to show your proposed geographical paths of disease spread. Propose either one, two, or three geographical pathways.

Students will propose up to three different geographical paths that the cholera may have spread throughout the country. Stress the importance of connecting the cities in chronological order for each separate path. Ideally, there will be one path following the northern border (starting near Calcutta), one through the central part of the country (Calcutta toward Bombay, then back inland a bit), and a third (which starts near Madras, connects to Calcutta, but also connects across the lower part of the peninsula).

Step 6:   a. How many paths does cholera take across India in the 1992–1993 epidemic? How do you know this? Cite specific data in your answer.

Answers may vary some, but students should have three main geographical paths, and should cite some of the chronological evidence as part of their answer.

b. Cholera is considered a waterborne bacterium. This means that one way it can spread is by starting upstream and flowing downstream towards the ocean. Zoom in on the map (if using Google Earth) and study areas of water flow. What do you notice about the location of bodies of water, their direction of flow, and the direction the cholera epidemic followed? Does following the water flow appear to be the main way the cholera spread in this outbreak? Explain.

There is usually a body of water near a cholera outbreak. However, in the case of this outbreak, either cholera is moving upstream or the outbreak is near a land-locked body of water. This means water may be related to the outbreak, but its flow is not how the outbreak spread. Further explanation should revolve around discussion of the geography of the Indian subcontinent. For instance, in the North pathway, cholera spreads against the flow of water; in the Central pathway, there are mostly intermittent lakes sparsely covering the middle of India; and the South pathway also does not seem to follow a flowing body of water, as is the most typical pattern of cholera's spread. Students may also notice that sometimes the epidemic reaches the coast and then turns back inland.

c. Consider the background information you read about cholera in Step 1. Do your observations about the paths the cholera outbreak still agree with this information? Cite at least two specific pieces of data that support your answer.

The observations do still agree, as water is instrumental in cholera breaking out in an area.

- The North pathway follows the Ganges and its tributary system.
- There are rivers and lakes near the cities that part part of the Central pathway.
- There are several bodies of water crisscrossing the southern tip of India (where the South pathway crosses).
- Students may be requested to give more specific information than this, if desired by the teacher.

Step 7:   a. Describe what you see.

Map Handout 1 shows the monsoon season wind patterns across India during the course of the outbreak of cholera. Data are presented in millibars of mercury (a common measurement of wind pressure).

b. India is subjected to a summer monsoon season, when severe storms and high winds are common. These winds often carry insects that can harbor (and not be affected by) some bacteria. Do you think the cholera pathways and the wind patterns match enough to support the authors' hypothesis? Explain.

The large arrows are in agreement with the timing of specific outbreaks along each of the paths. As stated in the study, wind patterns may have contributed significantly to this epidemic. If students do not have this as their answer, a reasonable answer should be considered for credit, particularly if their answers are supported by correct placement of data on their map.

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The bacteria do not harm the insects, but (as stated in the study) can be culturable a full 14 days after exposure to the bacterium. Monsoon-associated winds, as expected, tend to blow from the shore to inland areas, and this is shown in the pattern of cholera spread throughout India in 1992–1993.

Step 8: a. Suggest three things that might help prevent cholera outbreaks in the developing world, based on what you now know.

Actions that might help prevent cholera in the developing world:

- Adequately treat sewage.
- Boil water before drinking (or treat with iodine or chlorine).
- Thoroughly cook all foods that may have been exposed to the bacterium.
- Wash hands before eating.
- Provide sources of clean water for rehydration purposes.
- Make antibiotics more available in areas of outbreaks.
- Help spread water/sewage treatment technologies to areas not currently benefiting from their use.
- Prepare food with a known source of clean water.

b. Why do you think these things are not being done in places like India, Africa, and Latin America, where cholera is more prevalent?

Students need to have an understanding of developing and developed nations. Places with access to adequate sewage treatment and drinking water treatment have little problem with cholera. Student answers will vary, but main answers will include: high levels of poverty in the region, areas are too densely populated, people in these communities are less educated in issues involving health care, government funding is often not adequate to build an extensive high-quality sanitation infrastructure, good medical care is often unavailable (especially to the poor), rural areas have difficulty acquiring proper technology to prevent cholera (i.e., sanitation).

Step 9: Turn in a copy of your completed map with your answers to the questions above.

Check the printed map and paths added to it against Figure 3 from the full text version of the article. The number of cities has been reduced to 20 due to time constraints present in the classroom.

▶ Authors and Reviewers

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Give us your feedback! Send comments about this lesson to ehpscienceed@niehs.nih.gov.

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Step 1: Read the following information about epidemiology and cholera.

EPIDEMIOLOGY: Epidemiology is the science that investigates the cause and distribution of disease and illness in humans.

CHOLERA: Cholera is an infectious disease caused by a toxic bacterium (*Vibrio cholerae*). The bacterium infects the intestines and, in severe cases, causes diarrhea, leg cramps, and vomiting. This, in turn, causes rapid dehydration, which, if not addressed quickly, can lead to death, sometimes in mere hours.

Cholera is typically transmitted through water or food that is contaminated with the fecal matter of infected humans or animals. There are many potential ways the cholera can be transported from one location to another, causing an outbreak or epidemic (where lots of people get sick at the same time). Epidemics are common throughout the developing world and can result in considerable illness and death in these areas of the world. Cholera is practically unheard of in developed nations, which usually have water treatment and sanitation facilities that facilitate treatment and prevention.

Step 2: Read the abstract below from the *EHP* research article "Wind Direction and its Linkage with *Vibrio cholerae* Dissemination."

Abstract

Background: The relevance of climatic events as causative factors for cholera epidemics is well known. However, examinations of the involvement of climatic factors in intracontinental disease distribution are still absent.

Objectives: The spreading of cholera epidemics may be related to the dominant wind direction over land.

Methods: We examined the geographic diffusion of three cholera outbreaks through their linkage with the wind direction: a) the progress of *Vibrio cholerae* O1 biotype El Tor in Africa during 1970–1971 and b) again in 2005–2006 ; and c) the rapid spread of *Vibrio cholerae* O139 over India during 1992–1993. We also discuss the possible influence of the wind direction on windborn dissemination by flying insects, which may serve as vectors.

Results: Analysis of air pressure data at sea level and at several altitudes over Africa, India, and Bangladesh show a correspondence between the dominant wind direction and the intracontinental spread of cholera.

Conclusions: We explored the hypothesis that winds have assisted the progress of cholera Vibrios throughout continents. The current analysis supports the hypothesis that aeroplankton (the tiny life forms that float in the air and that may be caught and carried upward by the wind, landing far from their origin) carry the cholera bacteria from one body of water to an adjacent one. This finding may improve our understanding of how climatic factors are involved in the rapid distribution of new strains throughout a vast continental area. Awareness of the aerial transfer of *Vibrio cholerae* may assist health authorities by improving the prediction of the disease's geographic dissemination.

Step 3: Using a printed map or the software Google Earth (which allows you to interact with satellite images of the earth), you are going to plot the path of a cholera epidemic that occurred in India between October 1992 and July 1993. Then you will generate hypotheses about the paths the epidemic followed.

Note: If you are using printed maps, follow the steps with the words "PRINTED MAP INSTRUCTIONS." If you are using Google Earth, follow the steps with the words "GOOGLE EARTH INSTRUCTIONS."

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PRINTED MAP INSTRUCTIONS: Go to Step 4

GOOGLE EARTH INSTRUCTIONS:

- Open Google Earth from your computer desktop (it should already be downloaded and installed for use prior to the lesson).
- Search for India by clicking in the "Fly To" box, typing in "India," and clicking on the magnifying glass.
- Using the "View" tab, make sure that the sidebar and toolbar are showing.
- Now, zoom in using the "+" sign on the upper right side of the image so that India takes up most of the space in your Google Earth window.
- In the sidebar, under Layers, select (use the checkboxes): Terrain, Borders (all of the subheadings), Alternative Place Names, and under Geographic Features, check ONLY Water Bodies (access subheadings by clicking on the triangle to the left). All other headings should remain unchecked.

Step 4: PRINTED MAP INSTRUCTIONS: Table 1 shows the locations and dates where the cholera outbreak occurred in India between October 1992 and July 1993. Select a different color pushpin for each month, then label the locations on your map with the corresponding color.

GOOGLE EARTH:

- Use the "Fly To" function to add all of the cities in the data table below. It may be best to search the name of the city followed by "India." The map will start zooming into the location you typed; just click on the map to stop the zoom.
- Add a placemark (the "push pin") for each month using a different color placemark. To add a placemark, first select the "Push Pin" icon from the toolbar at the top of the map. Then name the placemark for each individual city in the data set. It helps to label the city and the month (e.g., Madras–Oct).
- Change the color of your placemark to correspond with the month. While the dialog box is still open, in the lower half of the box, there is a tab called "Style, Color." Select that, and then change the color of the icon AND the label. This makes it easier to differentiate later. Should you need to alter anything later, left click on the place name in the "Places" section of the sidebar and select "Properties."
- If Populated Places were left showing on your map, remove them now (in the Layers section of the sidebar).
- With the map taking up the entire window, all of the plotted points will be visible.

Table 1

Color	Month	Location 1	Location 2	Location 3	Location 4
	October 1992	Madras	Vellore		
	November 1992	Calcutta	Howrah	Madurai	
	December 1992	Amravati			
	January 1993	Nagpur			
	February 1993	Mysore			
	March 1993	Visakhapatnam			
	April 1993	Tirupati	Pune		
	May 1993	Bangalore	Alleppey	Bombay	Yavatmal
	June 1993	Lucknow	Delhi		
	July 1993	Ludhiana	Rohtak	Aurangabad	

Step 5:   Look at how the disease spread chronologically through India. Hypothesize a few possible routes by which the cholera bacterium may have spread through the country. Discuss these ideas with at least one other classmate before proceeding, if you're not already working in groups. Next, begin adding lines to show your proposed geographical paths of disease spread. Propose either one, two, or three geographical pathways.

PRINTED MAP INSTRUCTIONS:

- Using string, connect the pushpins in chronological order to show the paths you suspect the cholera outbreak followed across India.

GOOGLE EARTH INSTRUCTIONS:

- To add a path, select the appropriate tool from the toolbar (three square dots, arranged like the corners of a triangle). Click once, and a dialog box appears.

- Name each path (for example, hypothesis 1, hypothesis 2, hypothesis 3) as it is being made, while the box is still open. Click each city once, in the order you think the disease spread along that path. Each path should be given a different color to correspond with the color coding you used for labeling.

- The width of the line can also be changed (this will make it easier when answering the questions and printing). This is accomplished by clicking on the tab in the dialog box where you are placing your labels.

Step 6:   PRINTED MAP & GOOGLE EARTH INSTRUCTIONS (the same from this point forward):

Now inspect the entire map. Be sure the cities are connected in the correct chronological order. Answer the following questions:

a. How many paths does cholera take across India in the 1992–1993 epidemic? How do you know this? Cite specific data in your answer.

b. Cholera is considered a waterborne bacterium. This means that one way it can spread is by starting upstream and flowing downstream towards the ocean. Zoom in on the map (if using Google Earth) and study areas of water flow. What do you notice about the location of bodies of water, their direction of flow, and the direction the cholera epidemic followed? Does following the water flow appear to be the main way the cholera spread in this outbreak? Explain.

c. Consider the background information you read about cholera in Step 1. Do your observations about the paths the cholera outbreak still agree with this information? Cite at least two specific pieces of data that support your answer.

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Step 7:   Obtain Map Handout 1 from your teacher and review its contents.

a. Describe what you see.

b. India is subjected to a summer monsoon season, when severe storms and high winds are common. These winds often carry insects that can harbor (and not be affected by) some bacteria. Do you think the cholera paths and the wind patterns match enough to support the authors' hypothesis? Explain.

Step 8:   Cholera is a disease rarely encountered in the developing world.

a. Suggest three things that might help prevent cholera outbreaks in the developing world, based on what you now know.

b. Why do you think these things are not being done in places like India, Africa, and Latin America, where cholera is more prevalent?

Step 9:   Turn in a copy of your completed map with your answers to the questions above.

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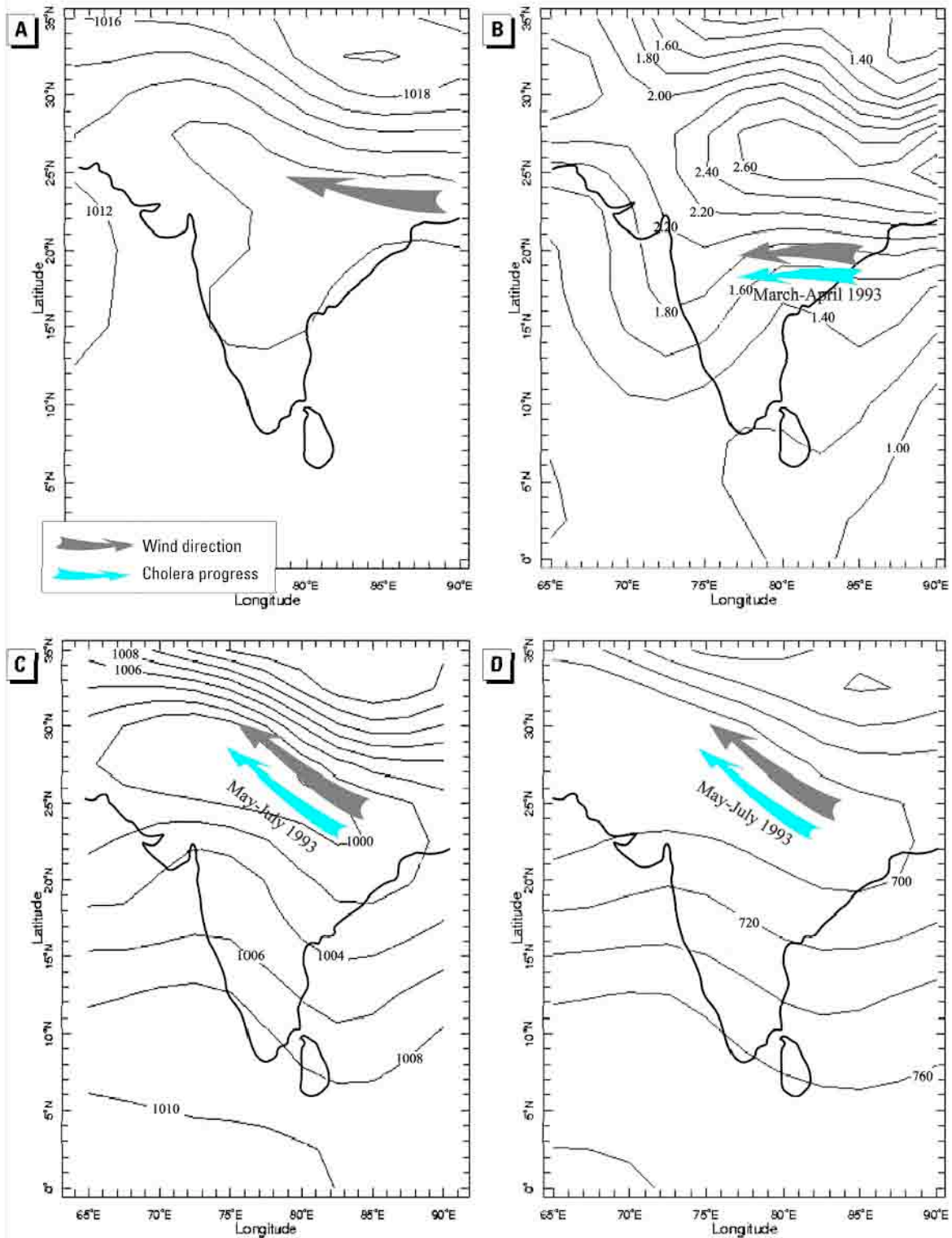*Community Outreach & Education Program*

Figure 4. Maps showing (*A*) mean SLP (in millibars) for 1951–2000; (*B*) deviations in SLP for March 1993 calculated based on the 1951–2000 averages for March; (*C*) mean monthly SLP for June 1993; and (*D*) dominant wind direction over northern India during June 1993 at the 925 mb level. Values in (*D*) indicate altitude in meters. Note how the geographic dissemination of *Vibrio cholerae* O139 corresponds to the dominant wind direction.